REVIEW OF THE CURRENT CALSIM II
VERNALIS SALINITY ALGORITHM

Executive Summary

Water quality standards, as defined by the Water Quality Control Plan of 1995, require the electrical-conductivity of the San Joaquin River at Vernalis to remain below 700 μmhos/cm (or μS/cm) during the April through August irrigation season and 1000 μmhos/cm during the September through March non-irrigation season. San Joaquin River salinity has traditionally been managed through water quality releases from the New Melones Reservoir; however, meeting the Vernalis salinity standard has become an ever-increasing challenge due to growing demands on the limited storage at New Melones. It is apparent that an accurate and more detailed method for estimating Vernalis salinity is essential, given that modeling studies for determining both supplemental and alternative methods for meeting San Joaquin water quality standards are being proposed. Studies potentially benefiting from an improved Vernalis salinity algorithm include:

1) A revised operations plan for New Melones Reservoir

2) Benefits of an enlarged Friant Reservoir

3) Total Maximum Daily Loads (TMDLs) on the Lower San Joaquin River

4) San Luis Drainage Project

5) Projects involving Delta salinity using Vernalis EC as an input

The purpose of this document is to review the Vernalis salinity algorithm currently used in CALSIM II. The algorithm uses a mass balance at Vernalis combining flow and electrical-conductivity from the San Joaquin River at Maze, Goodwin Releases, Stanislaus Accretions, Westside Returns, and other miscellaneous loadings. The review consists of two elements:

1) Comparing computed flow and salinity values from the CALSIM II Benchmark Study (September 30, 2002, Release; 2001 LOD, ANN Version) with historic flows and salinities at Vernalis in the form of a scatter plot

2) Applying historic flows of the San Joaquin and Stanislaus Rivers and Westside Returns to the CALSIM II Vernalis salinity mass balance. Time series plots of computed and historic salinities were then compared.

This document concludes with recommendations for possible improvements to the current Vernalis salinity mass balance and methods for creating a more detailed algorithm.

REVIEW OF THE CURRENT CALSIM VERNALIS SALINITY TECHNIQUE

1. Introduction

San Joaquin River salinity levels have traditionally been managed to meet water quality standards at Vernalis. The current salinity standard at Vernalis is defined by the 1995 Water Quality Control Plan and requires electrical-conductivity (EC) to remain below 700 μmho/cm and 1,000 μmho/cm during the April through August irrigation season and the September through March non-irrigation season, respectively. One objective of the New Melones Reservoir is to comply with water quality standards (dissolved oxygen and salinity) on the Stanislaus and San Joaquin Rivers. A chronological history of the New Melones Reservoir and the Vernalis salinity standard is shown below.

1926 - The Oakdale and South San Joaquin Irrigation Districts build the Melones Dam and Powerplant on the Stanislaus River.

1944 - *The Flood Control Act of 1994* authorized the U.S. Army Corps of Engineers to replace Melones Dam by constructing and operating a dam that would aid in alleviating serious flooding problems along the Stanislaus and Lower San Joaquin Rivers.[8]

1961 - *Public Law 87-88, The Federal Water Pollution Control Act Amendments of 1961* states "…in the survey or planning of any reservoirs for the Corps of Engineers, Bureau of Reclamation, or other Federal Agency, consideration shall be given to inclusion of storage for regulation of streamflow for the purpose of water quality control…"[6]

1962 - *Public Law 87-874, The 1962 Flood Control Act* states "…that the Secretary of the Army give consideration during the preconstruction planning of the New Melones Project to the advisability of including storage for the regulation of streamflow for the purpose of downstream water quality control…"[6]

1966 - Initial construction begins at the New Melones Dam site with initiation of the Access Roads, Overlook and Temporary Administration Area.

1969 - *Memorandum of Agreement for the Protection and Enhancement of the Water Quality of the Stanislaus and San Joaquin Rivers* ~ this document states the Bureau of Reclamation shall release from the New Melones Dam up to 70,000 acre-feet/year to meet dissolved oxygen objectives on the Stanislaus River and TDS objectives on the San Joaquin River. The TDS objective is specified as 500 mg/l (ppm) on the San Joaquin River at Vernalis.[6]

1973 - *Water Rights Decision D-1422* ~ the SWRCB specifies the salinity standard for the San Joaquin River at Vernalis shall not be greater than 500 ppm.[4]

1974 - Construction on the main dam commences; the dam will be located 0.75 miles downstream of the old Melones Dam. The impoundment of water behind the New Melones Dam will submerge the old dam.

1978 - The top of the embankment of New Melones Dam is completed.

1978 - *SWRCB D-1485* ~ provides water quality objectives intended to protect municipal and industrial, agricultural, and fish and wildlife beneficial uses in the Delta and Suisun Marsh. Water quality objectives for agricultural purposes in the southern Delta are not provided, as D-1422 already specified objectives for the San Joaquin River at Vernalis.[4]

1979 - New Melones Lake is transferred to the Department of the Interior as part of the Central Valley Project.

1983 – Initial filling of New Melones Reservoir commences.

1987 - *SWRCB WQ 85-1, Regulation of Agricultural Drainage to the San Joaquin River* ~ recommends a criterion of 700 μS/cm to fully protect irrigated agriculture and indicates salinity at or below this level should protect other beneficial uses, such as stock watering, fish, and wildlife. [1, 3]

1995 - *SWRCB WR 95-1, Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* ~ sets the electrical-conductivity standard for the San Joaquin River at Vernalis to 700 μS/cm for the irrigation period (April through August) and 1000 μS/cm for the non-irrigation period (September through March). [4, 5]

1996 - *New Melones Interim Operation Agreement* is set up as an interim plan of operation for the New Melones Reservoir. The plan establishes release caps for fisheries, water quality, X2 flows, and for CVP contractors. The release caps vary according to the February end-of-month storage plus the March through September forecast of inflow to New Melones.[7]

Sources:

1. CVRWQCB(2002)
2. SWRCB(1978)
3. SWRCB(1987)
4. SWRCB(1995)
5. SWRCB(2000)
6. USBR (1969)
7. USBR (1997)
8. USBR(2003)

2. **<u>The CALSIM II Salinity Mass Balance</u>**

The California Department of Water Resources and the Bureau of Reclamation have adopted the CALSIM II (hereby referred to as CALSIM) model as the primary tool for water planning studies in California. CALSIM currently computes salinity on the San Joaquin River only at Vernalis (Node 639). The computation uses a mass balance approach at Node 639, combining flow and electrical-conductivity from the San Joaquin River at Maze, Goodwin Releases, Stanislaus Accretions, Westside Returns, and other miscellaneous loadings (see Figure 2-1).

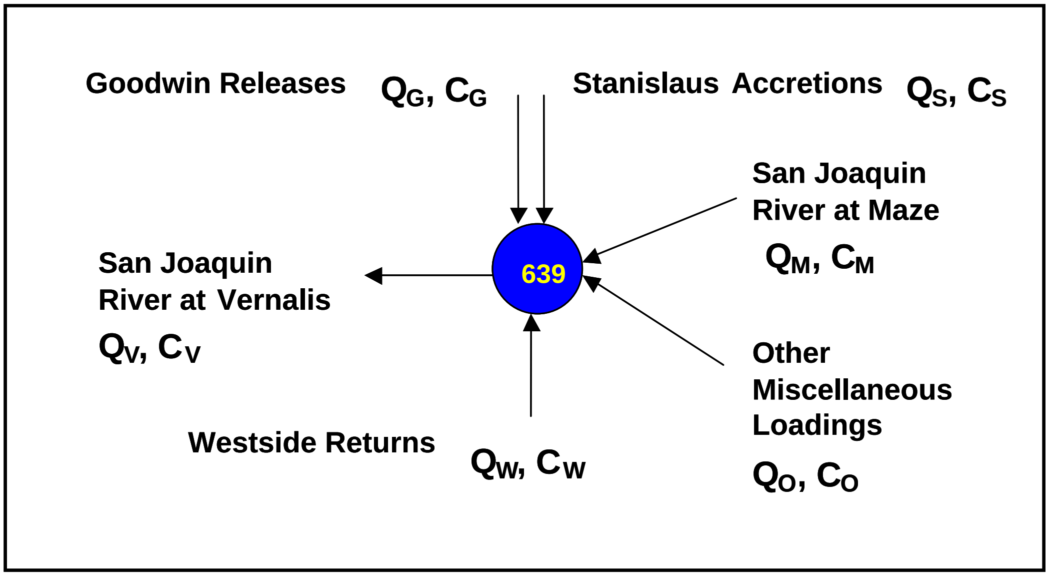

Figure 2-1
Mass Balance at Vernalis

The mass balance takes the form of the following equation:

$$C_V = \frac{(Q_M C_M + Q_G C_G + Q_S C_S + Q_W C_W + Q_O C_O)}{Q_V} \qquad (1)$$

where

Q_V = Vernalis Flow (cfs)
Q_M = Maze Flow (cfs)
Q_G = Goodwin Release Flow (cfs)
Q_S = Stanislaus Accretions Flow (cfs)
Q_w = Westside Return Flow (cfs)
Q_O = Other Miscellaneous Loading Flows (cfs)
C_V = Vernalis EC (µmho/cm)
C_M = Maze EC (µmho/cm)
C_G = Goodwin EC (µmho/cm)
C_S = Stanislaus Accretions EC (µmho/cm)
C_w = Westside Return EC (µmho/cm)
C_O = Other Miscellaneous Loading EC (µmho/cm).

It should be noted the Maze flow (Q_M) is not comparable to the actual measured flow of the San Joaquin River at the Maze Bridge. Maze flow is regarded as the San Joaquin River flow at the Maze Bridge minus the return flows from the Westside. In CALSIM the Maze flow is computed as follows:

$$Q_M = C639 - C528 - R638 + D639 - Q_W \qquad (2)$$

where
Q_M = Maze Flow (cfs)
C639 = Vernalis Flow (cfs, Cycle 6)
C528 = Stanislaus River at the Mouth Flow (cfs, Cycle 6)
R638 = Return Flow at Maze (cfs, Cycle 6)
D639 = Deliveries at Vernalis
Q_W = Westside Return Flows.

Goodwin Releases (Q_G) are taken from the CALSIM flow arc C16 for either Cycle 2 or Cycle 5, depending on whether Vernalis salinity is computed for the non-pulse flow or pulse flow period (or non-pulse flow DO period), respectively. Stanislaus Accretions are computed in CALSIM via the following equation:

$$Q_S = C530A + R523 + I524 - D524 - D525 + C531 \qquad (3)$$

where
C530A = Oakdale ID Return Flows
R523 = Modesto ID Return Flows to the Stanislaus River
I524 = Stanislaus River Accretions
D524 = Stanislaus River Depletions
D525 = Stanislaus River Riparian Diversions
C531 = Combined Return Flow of SSJID and Riparian Diversions.

Westside return flows are computed through a series of return flow arcs defined in CALSIM:

$$Q_W = R639 + R629 + R623C + R615 + C619 + I611 \qquad (4).$$

The individual agencies that are represented by the Westside return flows arcs are given in Table 2-1a. Table 2-1b shows the Mendota Pool return flow arcs that CALSIM does not include in the Westside returns (Q_W). Table 2-1c shows the DMC deliveries in CALSIM that do not drain into the San Joaquin River.

Table 2-1a
CALSIM Westside Return Flow Arcs

CALSIM Return Flow Arc	Representing Return Flows From
R639	Plainview WD
	City of Tracy
	Banta Carbona
	Westside WD
R629	Hospital WD
	Kern Canon WD
	West Stanislaus WD
R623C	Davis WD
	Del Puerto WD
	Salado WD
	Orestimba WD
	Patterson WD
	Foothill WD
	Quinto WD
	Romero WD
	Centinella WD
R615	Mustang WD
C619	Panoche WD (R712A)
	San Luis WD (R712A)
	Broadview WD (R712A)
	Laguna WD (R712A)
	Eagle Field WD (R712A)
	Mercy Springs WD (R712A)
	Oro Loma WD (R712A)
	Widren WD (R712A)
	Central California ID (R712B)
	San Luis WD (R712C)
	Panoche WD (R712D)
	Pacheco WD (R712D)
	DMC Exchange Contractors[1] (R619A)
	Sch II WR – Patterson (R619A)
	Sch II WR – Fresno Slough (R619A)
	Sch II WR – James ID (R619A)
	Sch II WR – Traction Ranch (R619A)
	Sch II WR – Tranquility (R619A)
	Sch II WR – Hughs, Melvin (R619A)
	Sch II WR – RD 1606 (R619A)

Table 2-1a (continued)
CALSIM Westside Return Flow Arcs

CALSIM Return Flow Arc	Representing Return Flows From
C619 (cont.)	Sch II WR – Dudley (R619A)
	Grassland via Volta Wasteway (R619B)
	Grassland via CCID (R619B)
	Grassland WD (R619B)
	Los Banos WMA (R619B)
	Los Banos WMA (R619B)
	Kesterson NWR via CCID (R619B)
	Kesterson via Volta Wasteway (R619B)
I611	Mud and Salt Slough Accretions

[1] Exchange Contractors consist of Central California Irrigation District, San Luis Canal Company, Firebaugh Canal Water District and Columbia Canal Company

Table 2-1 b
CALSIM Mendota Pool Return Flow Arcs

CALSIM Delivery Flow Arc	Representing Deliveries for
R608A	Westlands WD (incl. Bacellos)
	Fresno Slough WD
	James ID
	Traction Ranch/Casper
	Tranquility ID
	Hughes, Melvin
	RD 1606
R608B	DMC Exchange Contractors
	Sch II WR – Patterson
	Sch II WR – Fresno Slough
	Sch II WR – James ID
	Sch II WR – Traction Ranch
	Sch II WR – Tranquility
	Sch II WR – Hughs, Melvin
	Sch II WR – RD 1606
	Sch II WR – Dudley
R608C	Grassland WD
	Los Banos WMA
	San Luis NWR
	Mendota WMA
	West Gallo SJBAP

Table 2-1 c.
CALSIM DMC Deliveries with no Return Flow Arcs

CALSIM Delivery Flow Arc	Representing Deliveries for
D708	Freitas – SJBAP
	Salt Slough – SJBAP
	China Island – SJBAP
	Volta WMA
	Sunflower WD

Electrical-conductivity for Equation (1) is defined for both the non-irrigation season (October through February) and irrigation season (March through September). The flow/salinity relationship for the San Joaquin River at Maze is estimated by the Modified Kratzer Equation that takes the form:

$$C_M = K_1 * V_M^{-K_2} \qquad (5)$$

where
C_M = Maze EC (μmho/cm)
V_M = Maze Flow Volume (acre-feet)
K_1 = Water Quality Multiplier #1
K2 = Water Quality Multiplier #2.

The original Kratzer Equation was developed by the SWRCB in 1990 using calculated flow and EC data from the period 1986-1989. In 1995, the Kratzer Equation was modified by the Bureau of Reclamation by subtracting the Westside returns. For this modification it was assumed that Westside return flows were the lesser of 20,000 acre-feet, or 35% of the monthly flow at Maze during October to February and the lesser of 20,000 acre-feet, or 60% of the monthly flow at Maze during March to September. It was also assumed that the TDS was 1,700 ppm during October to February and 1,500 ppm from March to September. The values for K_1 and K_2 for the Modified Kratzer Equation, along with C_G, C_S and C_W for the non-irrigation and irrigation season, are given in Table 2-2.

Table 2-2
EC Values for Non-Irrigation and Irrigation Seasons

Salinity Component	Non-Irrigation EC (μmho/cm, Oct-Feb)	Irrigation EC (μmho/cm, Mar-Sep)
Goodwin Salinity (C_G)	85	85
Stanislaus Accretions (C_S)	380	190
Westside Returns (C_W)	2,300	2,300
Kratzer Equation K_1	866,201.49	54,645
Kratzer Equation K_2	-0.69289	-0.44346

The Vernalis flow/salinity algorithm is contained in the file WQ_Bound.wresl (see Appendix). The CALSIM variables representing flows and EC in Equation (1) are defined in Tables 2-3a and 2-3c for the non-pulse flow and pulse flow periods, respectively. Additional miscellaneous flows and EC (Q_O, C_O) are defined in Tables 2-3b and 2-3d for the non-pulse flow and pulse flow periods. The plus and minus signs preceding the CALSIM flow variable indicate whether the component is to be either added or subtracted in the mass balance.

Table 2-3a
Flows and Salinity Variables used in
the Vernalis Salinity Algorithm (For Non-Pulse Flow Period)

Mass Balance Components	CALSIM Flow Variable	CALSIM Salinity Variable
Vernalis Flow (Q_V)	FlowC639woD639	
Maze Flow ($Q_{M,}$ C_M)	+ MainStemNonPulse	MainStem_EC_finalnp
Stanislaus Accr ($Q_{S,}$ C_S)	+ ACCR (Cycle 2 or 5)[1]	ACCR_EC
Goodwin Release ($Q_{G,}$ C_G)	+ C16 (Cycle 2 or 5)[1]	GOOD_EC
Westside Rtn. (Q_W,C_W)	+ WestSideNonPulse	Westside_EC

Table 2-3b
Other Miscellaneous Loadings (Q_O,C_O) used in
the Vernalis Salinity Algorithm (For Non-Pulse Flow Period)

Mass Balance Components	CALSIM Flow Variable	CALSIM Salinity Variable
Return flow at Maze	+ R638(Cycle 2 or 5)[1]	MainStem_EC_finalnp
New Melones X2 Release	+ VernMin_reqtobemet	GOOD_EC
Merced Oct. SJRA Flows	+ MercedRelease_Oct	GOOD_EC
OID Water Purchases	+ OIDInstreamToBeMet	GOOD_EC

Table 2-3c
Flows and Salinity Variables used in
the Vernalis Salinity Algorithm (For Pulse Flow Period)

Mass Balance Components	CALSIM Flow Variable	CALSIM Salinity Variable
Vernalis Flow (Q_V)	pulseC639woD639	
Maze Flow ($Q_{M,}$ C_M)	+ MainStemPulse	MainStem_EC_finalpulse
Stanislaus Accr ($Q_{S,}$ C_S)	+ ACCR (Cycle 5)	ACCR_EC
Goodwin Release ($Q_{G,}$ C_G)	+ C16 (Cycle 5)	GOOD_EC
Westside Rtn. (Q_W,C_W)	+ WestSideNonPulse	Westside_EC

Table 2-3d
Other Miscellaneous Loadings (Q_O,C_O) used in
the Vernalis Salinity Algorithm (For Pulse Flow Period)

Mass Balance Components	CALSIM Flow Variable	CALSIM Salinity Variable
Tuolumne VAMP Release	+ C81 (Cycle 5)	GOOD_EC
Merced VAMP Release	+ C20 (Cycle 5)	GOOD_EC
Stanislaus VAMP Release	+ C16 (Cycle 5)	GOOD_EC
New Melones redirection to MID	- D16(Cycle5)	GOOD_EC
Return flow at Maze	+ R638(Cycle 5)	MainStem_EC_finalpulse
Mainstem Cycle 6 to Cycle 2 Translation	- MainCyc6Cyc2Trans[2]	MainStem_EC_finalpulse
Mainstem Cycle 6 to Cycle 2 Translation	+ MainCyc6Cyc2Trans[2]	GOOD_EC
OID Water Purchases	+ OIDInstreamToBeMet[3]	GOOD_EC
SJR ERPP Flows	+ SJRERPPinflows[4]	GOOD_EC

Footnotes:
[1] Cycle 2 used for February-May non-pulse period and
Cycle 5 used for June-September non-pulse period with Stanislaus DO releases
[2] MainCyc6Cyc2Trans consists of the function:
max (0.,C81m[VAMP_AND_DO] - C81m[SJR_WQ1]- min (0., mainstem[VAMP_AND_DO])
- Demand_D624 - Demand_D625 - Demand_D639
[3] Multiplied by 30/16 for April and 31/15 for May
[4] Only occurs in May. Multiplied by 10/15 for May

3. Comparison of CALSIM Generated and Historic Salinities

A comparison was made between CALSIM generated salinities and historic salinities at Vernalis. The CALSIM study used was the 2001 Level of Development, ANN Benchmark (released September 30, 2002). CALSIM-generated salinities and observed salinities can only be compared by means of flow-salinity scatter plots. Direct comparison of time-series plots would not be valid since computed flows from CALSIM do not necessarily reflect historic operations on the San Joaquin River; however, a scatter plot will depict the flow-salinity relationship independent of time. If the flow-salinity relationship determined by CALSIM sufficiently replicates the historic flow-salinity relationship, the two clouds of scatter points should overlap each other.

Figure 3-1 shows a scatter plot of computed CALSIM flows and salinities (red diamonds) for the period 1922-1994 and observed flows and salinities (blue triangles) for the period 1965-2001. Also shown on the plot are best-fit regression curves for the CALSIM data (yellow line) and observed data (light blue line). The data points illustrate there is a reasonable overlap of CALSIM data over observed data.

There appears to be a few observed data points that fall outside the cloud of CALSIM data in the middle flow range (3,000 to 15,000 cfs), but these points are limited in number. The regression curves show CALSIM has a tendency to overestimate low flow salinities and underestimate salinity at high flows. Figure 3-2 shows a log-log plot of these data. The crossing point of overestimating to underestimating appears to be around 3,000 to 4,000 cfs.

4. Application of Historic Flows to the Mass Balance

The scatter plots in Section 3 offer valuable insight regarding the tendency of the CALSIM Vernalis EC mass balance to either overestimate or underestimate salinity for different flow regimes. However, the scatter plots do not provide insight as to what months the mass balance would over or underestimate EC, nor the magnitude of the differences when compared to observed data. To obtain this information, time series plots are necessary and flows representing historical operations are required for the mass balance equation.

To perform the historic mass balance, San Joaquin River flow data (compiled by MBK Engineers[1]) was applied to the Vernalis EC equation. Observed flow data was collected for several stations along the San Joaquin River and its tributaries for the period 1922-1999. Flow values were generated synthetically through water balances or other means for stations without a complete period of record. Vernalis flow was comprised of the following components for this analysis:

$$Q_V = Q_M + Q_G + Q_{S1} - Q_{D1} + Q_{R1} - Q_{D2} + Q_{R2} + Q_{R3} - Q_{D3} + Q_{S2} + Q_W \qquad (6)$$

where

Q_V = San Joaquin River at Vernalis flow
Q_M = San Joaquin River at Maze flow
Q_G = Stanislaus River at Goodwin Dam release flow
Q_{S1} = Stanislaus River Accretion flow (Goodwin to Ripon)
Q_{D1} = Upper Stanislaus Diversions (10% of total Stanislaus diversions)
Q_{R1} = Modesto ID Return Flows to the Stanislaus
Q_{D2} = Lower Stanislaus Diversions (90% of total Stanislaus diversions)
Q_{R2} = Modesto ID Return Flows below Ripon and Maze
Q_{D3} = San Joaquin Riparian Diversions between Maze and Vernalis
Q_{R3} = San Joaquin Riparian Return Flows between Maze and Vernalis
Q_{S2} = San Joaquin River Accretion flow between Maze/Ripon to Vernalis)
Q_W = Westside Return flow (Developed by Dan Steiner).

Flow data sources are summarized in Table 4-1. These data were applied directly to the mass balance without adjustments to the magnitudes.

[1] Collected by Walter Bourez and Dan Steiner of MBK Engineers for the CALSIM 2030 Hydrology Project.

Table 4-1
Sources of Flow Data

Flow Component	Period Of Record	MBK Spreadsheet File
Maze Flow	1960-1993[2]	SJR_main_071602.xls
Goodwin Release	1957-1999	Stan_071602.xls
Stanislaus Accretion	1922-1998[3]	Stan_071602.xls
Upper Stanislaus Diversions	1958-1970[4]	Stan_071602.xls
Modesto ID Return Flows (Stanislaus River)	1990-2000[5]	Stan_071602.xls
Lower Stanislaus Diversions	1928-1970[4]	Stan_071602.xls
Modesto ID Return Flows (Below Maze & Ripon)	1990-2000[6]	SJR_main_071602.xls
San Joaquin Riparian Diversions (below Maze)	1928-1970[7]	SJR_main_071602.xls
San Joaquin Riparian Returns (below Maze)	1922-1998[8]	SJR_main_071602.xls
San Joaquin Accretion	1960-1993[3]	SJR_main_071602.xls
Westside Returns	1922-1998[9]	WSDelivnRet9_19_02.xls

[2] Estimated for 1994-1998 through water balance
[3] Computed from water balance
[4] Estimated for 1971-1998 from historic data averages
[5] Estimated from historic data averages for period before 1990
[6] Period before 1990 approximated from 0.65% of total Modesto Returns
[7] Taken as 5% of total San Joaquin River diversions. Historical total San Joaquin River diversions provided by DWR Bulletin 123 and 130. Total San Joaquin River diversions are estimated for 1971-1998 from historic data averages
[8] Estimated as 30% of riparian diversions between Maze, Ripon, and Vernalis
[9] Approximated by Dan Steiner

Electrical-conductivity values associated with the flow components were the same as those used in CALSIM (Table 4-2). The flow and salinity values were applied to the mass balance equation given by:

$$C_V = \frac{\begin{pmatrix} Q_M C_M + Q_G C_G + Q_{S1} C_{S1} - Q_{D1} C_{D1} + Q_{R1} C_{R1} - Q_{D2} C_{D2} \\ + Q_{R2} C_{R2} - Q_{D3} C_{D3} + Q_{R3} C_{R3} + Q_{S2} C_{S2} + Q_W C_W \end{pmatrix}}{Q_V} \quad (7).$$

Table 4-2
Mass Balance EC Values

EC Component	Value Non-Irrigation Season EC (µmho/cm)	Value Irrigation Season EC (µmho/cm)
Maze EC (C_M)	Kratzer Equation[10]	Kratzer Equation[10]
Goodwin Release EC (C_G)	85	85
Stanislaus Accretion EC (C_{S1})	380	190
Upper Stanislaus Diversions (C_{D1})	85	85
Modesto ID Return Flows (Stanislaus River) (C_{R1})	380	190
Lower Stanislaus Diversions (C_{D2})	Computed Ripon EC[11]	Computed Ripon EC[11]
Modesto ID Return Flows (Below Maze & Ripon) (C_{R2})	380	190
San Joaquin Riparian Diversions (below Maze) (C_{D3})	Kratzer Equation[10]	Kratzer Equation[10]
San Joaquin Riparian Returns (below Maze) (C_{R3})	2,300	2,300
San Joaquin Accretion EC (C_{S2})	380	190
Westside Returns EC (C_W)	2,300	2,300

[10] Used the same K_1 and K_2 values as CALSIM
[11] Computed with EC mass balance at Ripon

Figures 4-1 through 4-7 illustrate the time series plots for the period 1965-1998. Figure 4-1 shows both computed and observed flows (red and blue lines) and the computed and observed EC (yellow and light blue lines) for the period 1965-1969. The computed and observed flows at Vernalis appear to coincide, with a slight tendency for the computed flow to exceed the observed flow.

The salinities also seem to correspond for most months, with the computed value subject to overestimating EC during the low flow periods of June-August 1966 and June-August 1968. This trend is consistent with the CALSIM scatter plots presented in Section 3.

Figure 4-2 shows the plot for the period 1970-1974. The consistent trend of computed flow exceeding the observed flow is more apparent with the finer axis scaling. Yet again, the salinity mass balance appears to over-predict during low flows (July-August 1971 and April-August 1972) and under-predict during high flows (January-February 1970, January-February 1971, January-April1973, and January-April 1974). Under predictions of EC during high flows could be the result of salt loadings from rainfall runoff, which is not considered in the mass balance. For the periods 1975-1979 and 1980-1984 (Figures 4-3 and 4-4), the salinity mass balance appears to perform satisfactorily with the exception of a prolonged low flow period from October 1976 through December 1977.

The plots in Figures 4-5 (1985-1989) and 4-6 (1990-1994) illustrate another period of prolonged low flows. During this interval, a reverse trend occurred as the salinity mass balance appeared to underestimate EC the majority of the time. This change in trend may represent varying land use or drainage practices on the Westside. The mass balance also appeared to miss several EC peaks during the late fall and early winter. This could indicate the constant CALSIM EC values require further seasonal variability beyond the irrigation and non-irrigation season. The trend of underestimating EC continues into the period 1995-1998 (Figure 4-7).

Scatter plots of computed vs. observed EC (1965-1998) for October through December are presented in Figures 4-8 to 4-18. The scatter plots show a clear underestimation of computed EC for the months of November to March (Figures 4-8 through 4-13). A more even distribution of scatter points above and below the 45-degree line is displayed in April and May (Figures 4-14 through 4-15). The months of June, July and August show a tendency for the computed EC to exceed the observed EC. Statistics on the flow and EC differences are displayed in Tables 4-3 and 4-4. The average EC differences for the period 1985-1998 appear larger than for the fall and winter months of 1965 through 1984.

Table 4-3
Statistics for Flow Differences (Computed – Observed)

	(1965-1998)			(1965-1984)			(1985-1998)		
Month	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max
October	284	92	308	297	113	308	264	92	308
November	245	64	266	248	64	266	241	131	266
December	266	84	1594	300	84	1594	217	84	240
January	194	90	208	196	90	208	190	90	208
February	253	-214	317	250	-214	317	258	-89	317
March	394	373	458	396	373	458	390	373	394
April	411	315	441	415	316	421	407	315	441
May	354	215	369	360	215	369	346	215	368
June	364	215	383	372	215	383	352	215	383
July	405	222	423	413	222	423	393	222	423
August	407	193	428	416	193	428	393	193	428
September	245	83	285	269	91	285	212	83	278

Table 4-4
Statistics for EC Differences (Computed – Observed)

	(1965-1998)			(1965-1984)			(1985-1998)		
Month	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max
October	4	-426	376	19	-426	376	-15	-346	77
November	-95	-481	230	-90	-481	230	-102	-213	60
December	-159	-367	257	-120	-297	257	-203	-367	-50
January	-264	-814	-56	-237	-814	-92	-298	-551	-56
February	-235	-649	-68	-192	-649	-78	-290	-570	-68
March	-130	-514	224	-64	-267	224	-216	-514	-32
April	-32	-268	506	-10	-192	506	-63	-268	140
May	35	-92	292	36	-92	270	33	-59	292
June	108	-92	852	138	-92	852	65	-59	441
July	171	-39	862	190	-37	862	144	-39	490
August	146	-275	435	151	-275	435	140	-113	329
September	23	-143	197	36	-71	197	4	-143	137

5. Conclusions and Recommendations

The CALSIM salinity mass balance equation gives a satisfactory estimate of electrical-conductivity in the San Joaquin River at Vernalis. The mass balance tends to under-estimate salinity for the late fall and winter months and over-estimate during the summer months. It appears to perform better for the period 1965 to 1984 than for the period 1985 to 1998. The following suggestions provide possible refinements to the Vernalis salinity computation:

1) Developing seasonally and geographically based EC values for the Westside returns. The northern Westside region may have different return flow salinities than the southern region. Data are currently available for the Grasslands Drainage Area and Mud and Salt Slough. Additional data should be collected, especially for the northern water districts. The data could be collected by Nigel Quinn and a graduate student from Lawrence Berkeley Lab.

2) Computing Vernalis salinity in CALSIM using a link-node approach, thus removing the need for the Modified Kratzer Equation. In this case, salinity would be computed further upstream on the San Joaquin River near Stevinson (Lander Avenue), similar to the SJRIO and DSM2 models. This location is situated upstream of Mud and Salt Slough and is not influenced by Westside drainage. Salinity would be computed at each CALSIM main-stem node (a total of 6) via mass balance and progressively marched downstream to Vernalis. This is an extremely data intensive approach, since an EC value would be required for each tributary, accretion, or return flow that enters a node. If the EC values were estimated incorrectly, the resulting error in computed salinity would propagate downstream to Vernalis.

Sources of EC data for approach number (2) can be obtained from the following various sources: (1) collecting salinity data from the Eastside and Westside water districts, (2) site visits using EC probes, and (3) performing statistical analyses for developing flow-salinity relationships that could be applied to CALSIM. Undoubtedly, additional data would be collected over the years to ensure the robustness of the statistical equations. In the absence of further data collection, current flow-salinity equations from the DSM2 model could be applied. The Department of Water Resources (DWR) recently developed a DSM2 model of the San Joaquin River using statistical equations for the Eastside tributaries and EC estimates for the Eastside and Westside water districts.

Initially, the link-node water quality algorithm for CALSIM should be developed in a spreadsheet. The spreadsheet model would be developed using the historical flow data collected by MBK Engineers. Computed Vernalis salinity from the link-node approach should be compared to observed salinity and salinity from the mass balance equation. Once the spreadsheet is completed and flow-EC relationships verified, the algorithm would then be programmed into CALSIM with WRESL code.

6. References

CVRWQCB(2002), *Total Maximum Daily Load for Salinity and Boron in the Lower San Joaquin River*, California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region, January 2002.

SWRCB(1978), Water Right Decision 1485, Sacramento-San Joaquin Delta and Suisun Marsh, California State Water Resources Control Board, August 1978.

SWRCB(1987), *Regulation of Agricultural Drainage to the San Joaquin River*, California State Water Resources Control Board, WQ 85-1, August 1987.

SWRCB(1995), *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*, California State Water Resources Control Board, WR 95-1, May 1995.

SWRCB(2000), *Revised Water Right Decision 1641*, California State Water Resources Control Board, WR 2000-02, March 15, 2000.

USBR (1969), *Memorandum of Agreement for the Protection and Enhancement of the water quality of the Stanislaus and San Joaquin Rivers as affected by the New Melones Project Under Water Right Affiliation 19304 of the United States of America and by Municipal and Industrial Wastes*, United States Department of Interior, Bureau of Reclamation, New Melones Unit, Central Valley Project, California, July, 2, 1969.

USBR(1997), *Transmittal Letter of New Melones Interim Plan of Operation*, USBR CVOO letter from Lowell Ploss addressed to the Stanislaus River Basin Stakeholders, May 1997.

USBR (2000), *SANJASM Water Quality Computations*, documentation paper by Huxley Madeheim dated June 14, 2000.

USBR(2003), *CVP-East Side Division New Melones Unit - CA*, Bureau of Reclamation DataWeb web site, http://dataweb.usbr.gov/dams/ca10246.htm .

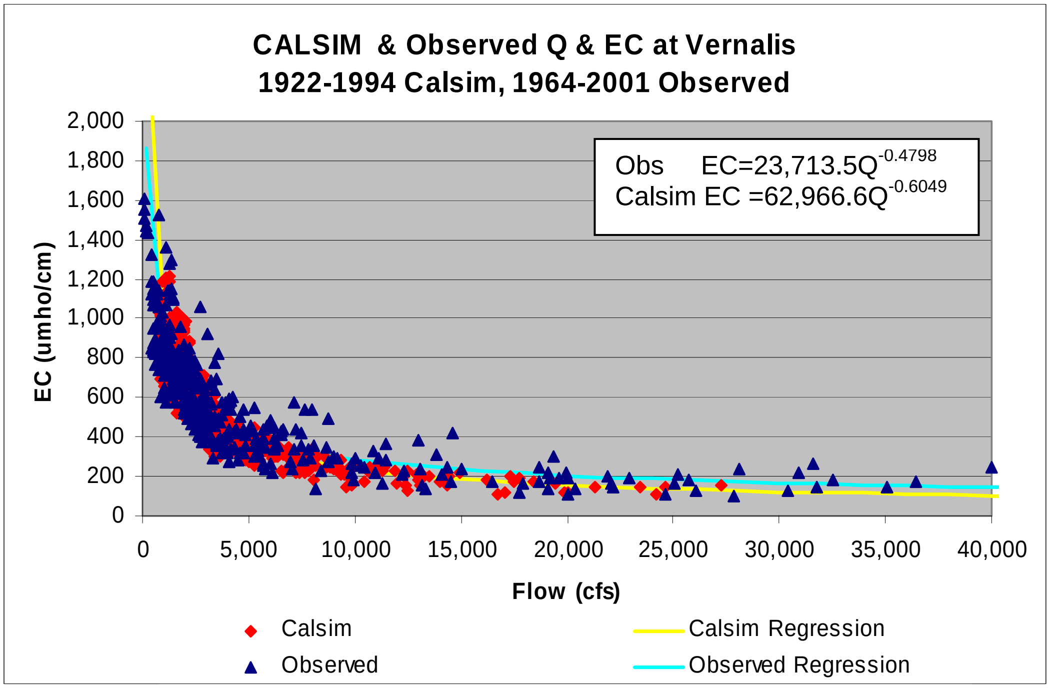

Figure 3-1
CALSIM (1922-1994) and Historic (1964-2001) Flows and Salinities

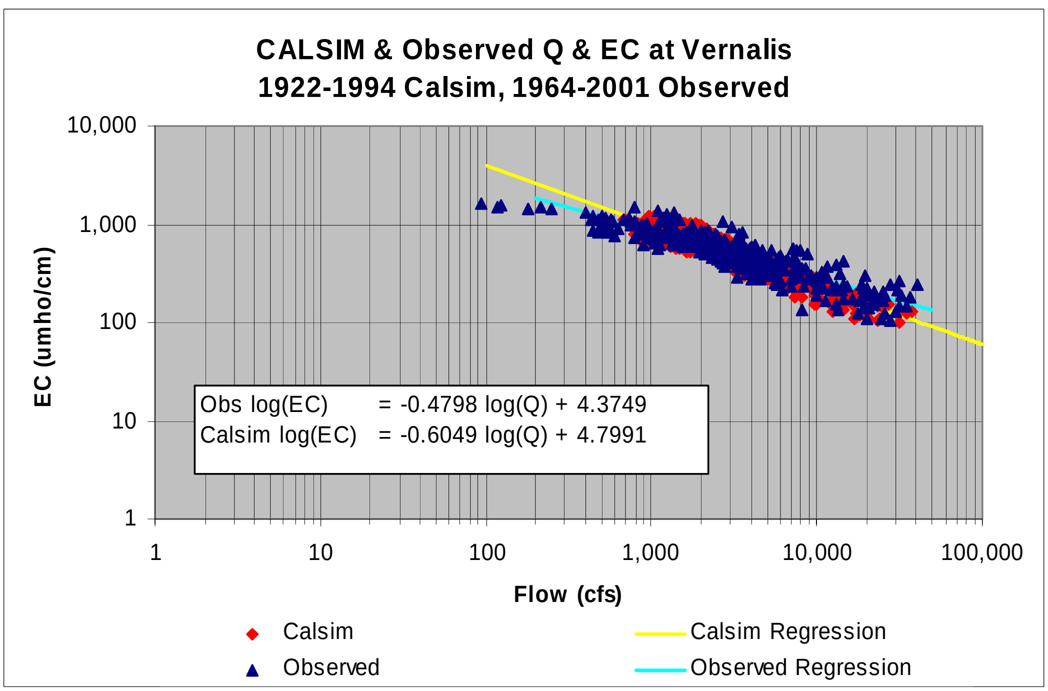

Figure 3-2
CALSIM (1922-1994) and Historic (1964-2001) Flows and Salinities
Log-Log Plot

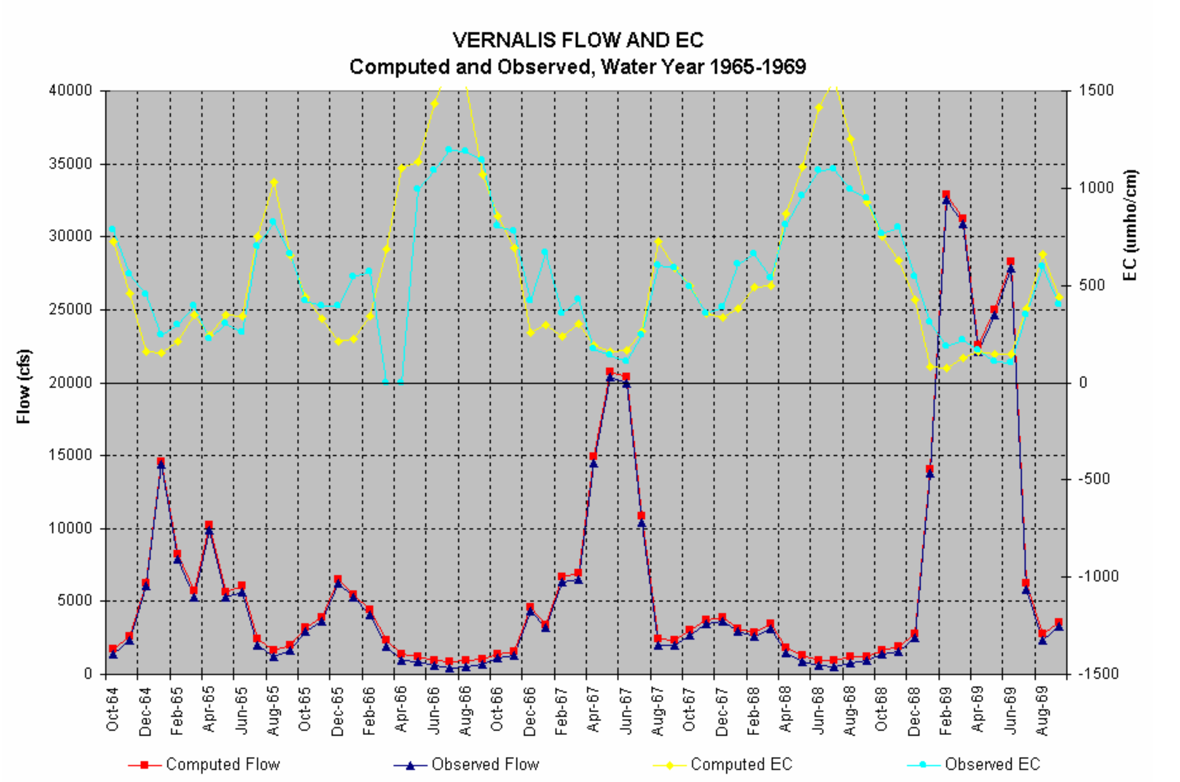

Figure 4-1
Time Series of Historic Flow and EC (1965-1969)

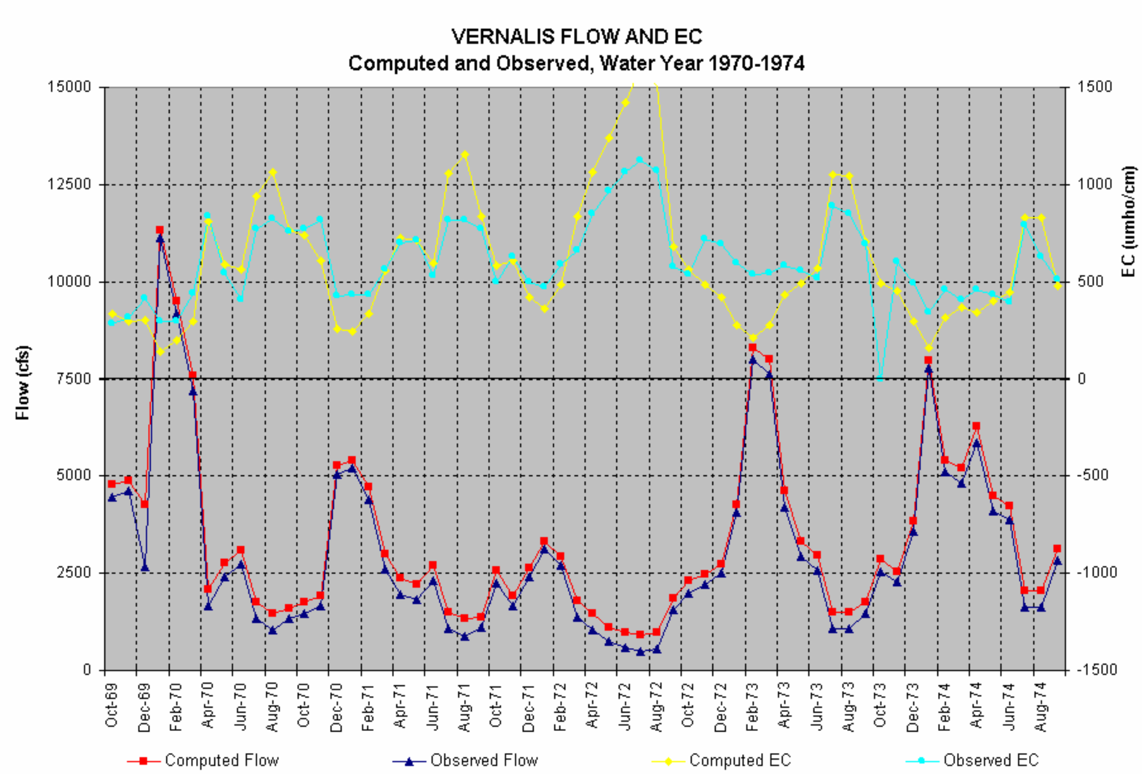

Figure 4-2
Time Series of Historic Flow and EC (1970-1974)

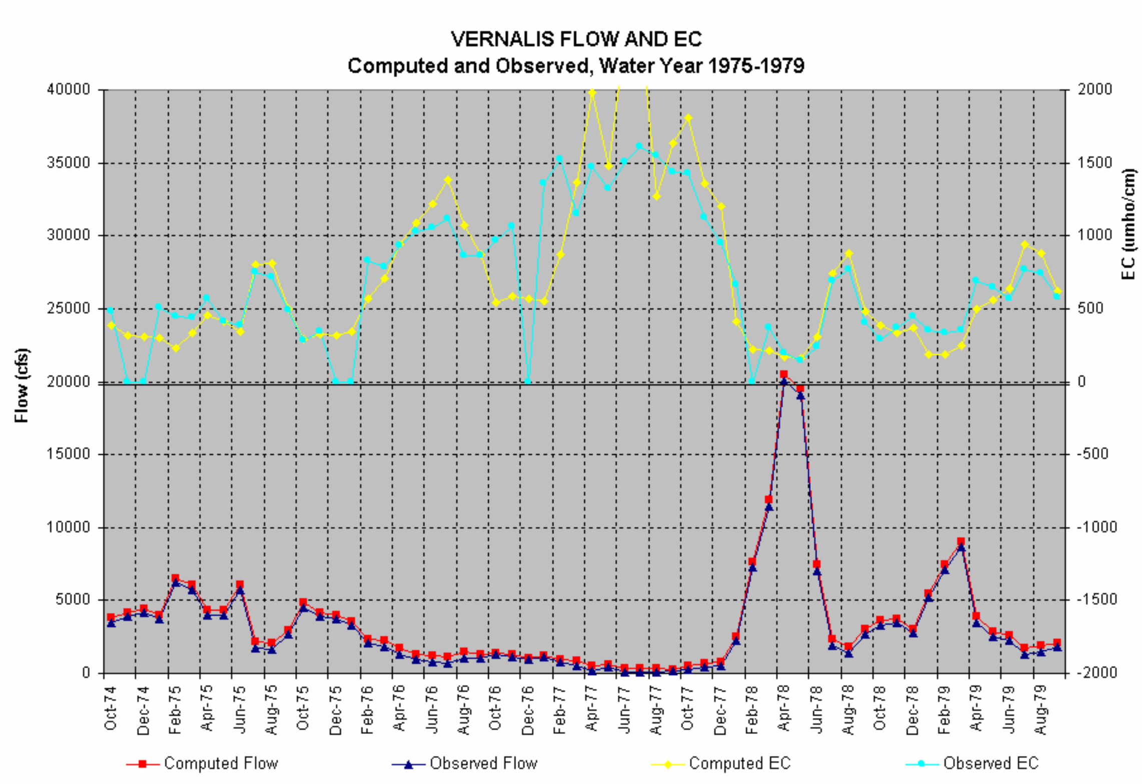

Figure 4-3
Time Series of Historic Flow and EC (1975-1979)

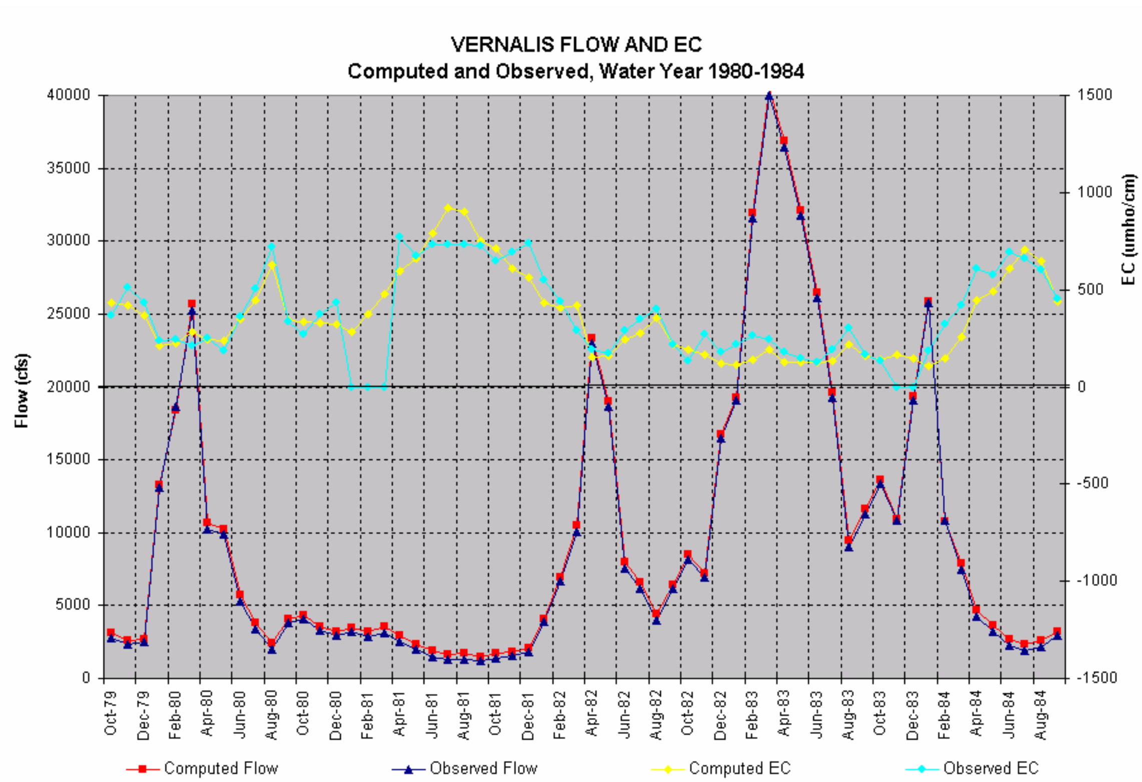

Figure 4-4
Time Series of Historic Flow and EC (1980-1984)

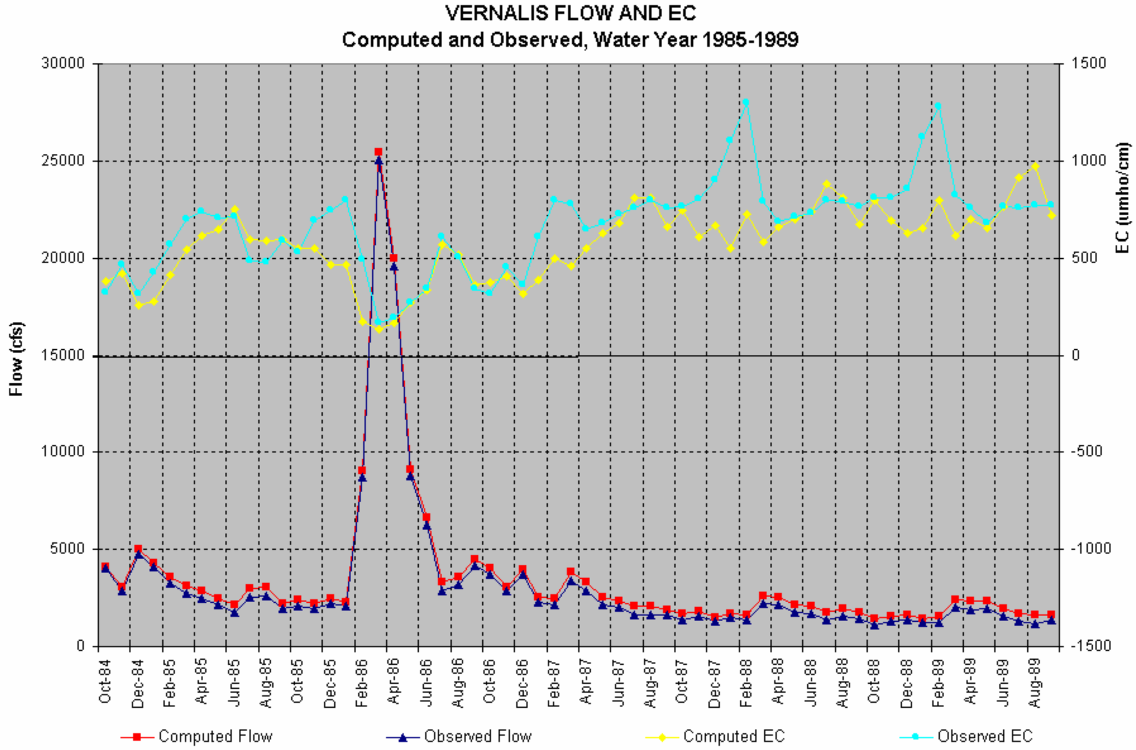

Figure 4-5
Time Series of Historic Flow and EC (1985-1989)

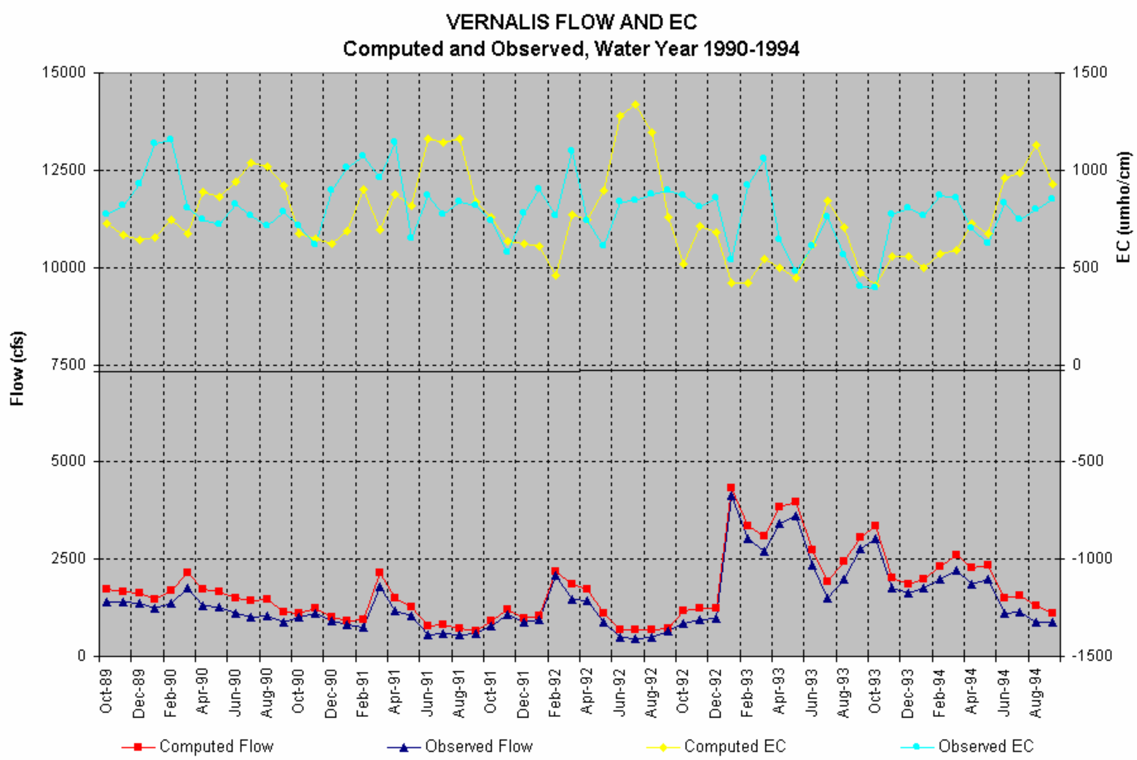

Figure 4-6
Time Series of Historic Flow and EC (1990-1994)

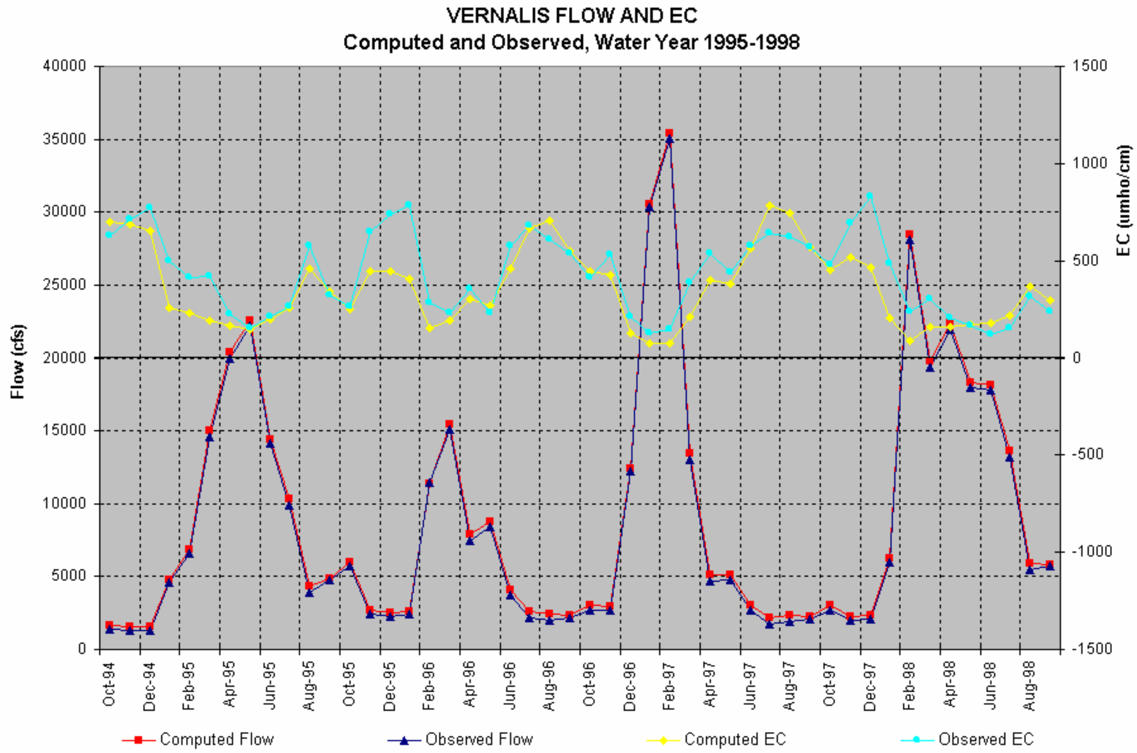

Figure 4-7
Time Series of Historic Flow and EC (1995-1998)

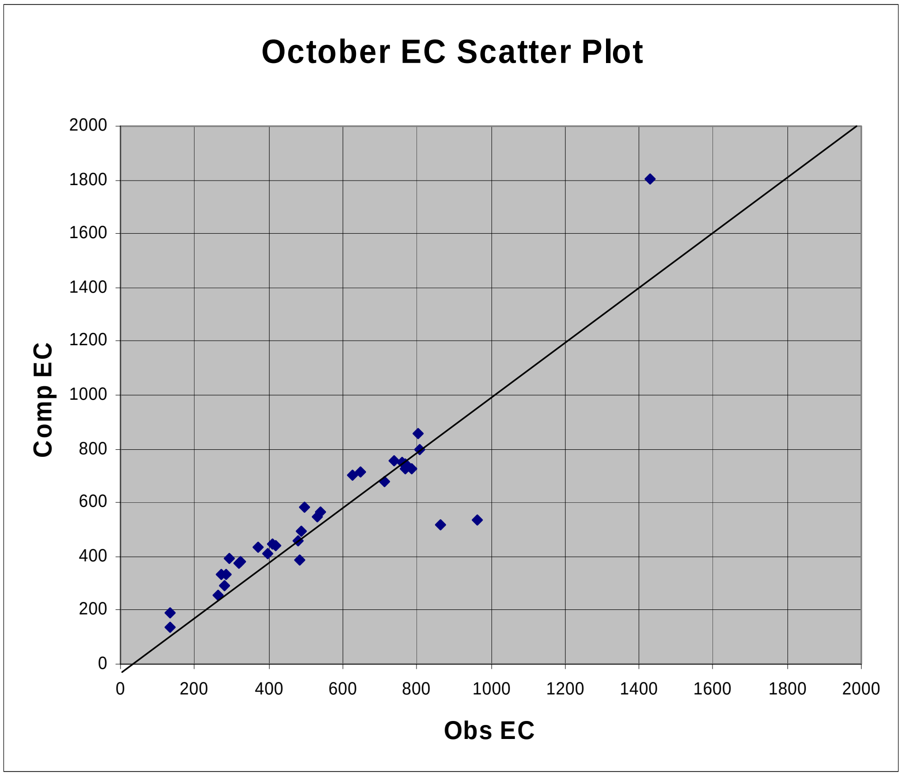

Figure 4-8
October EC Scatter Plot

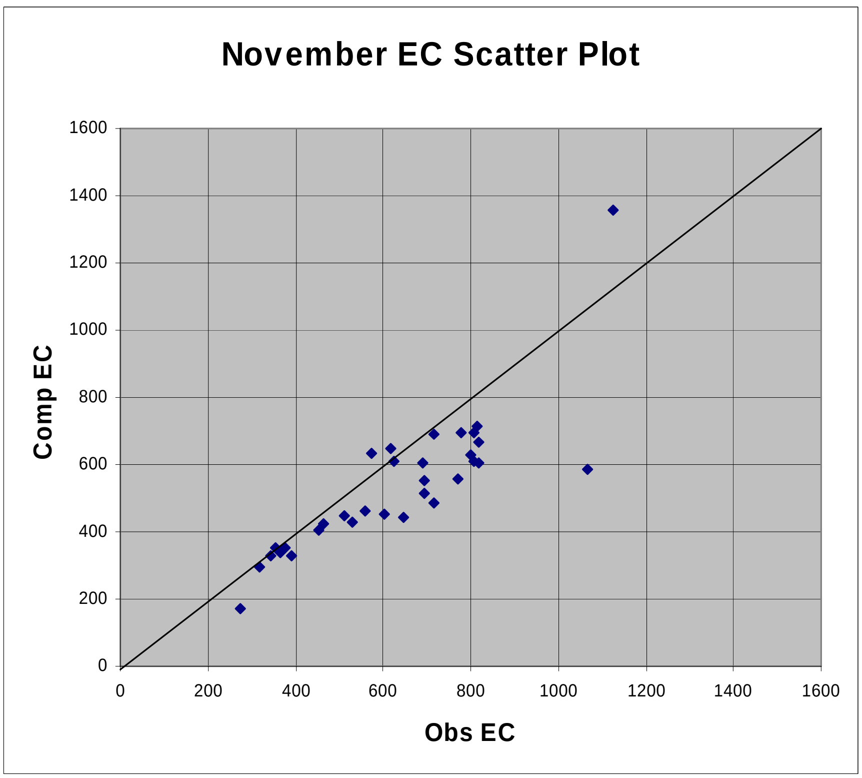

Figure 4-9
November EC Scatter Plot

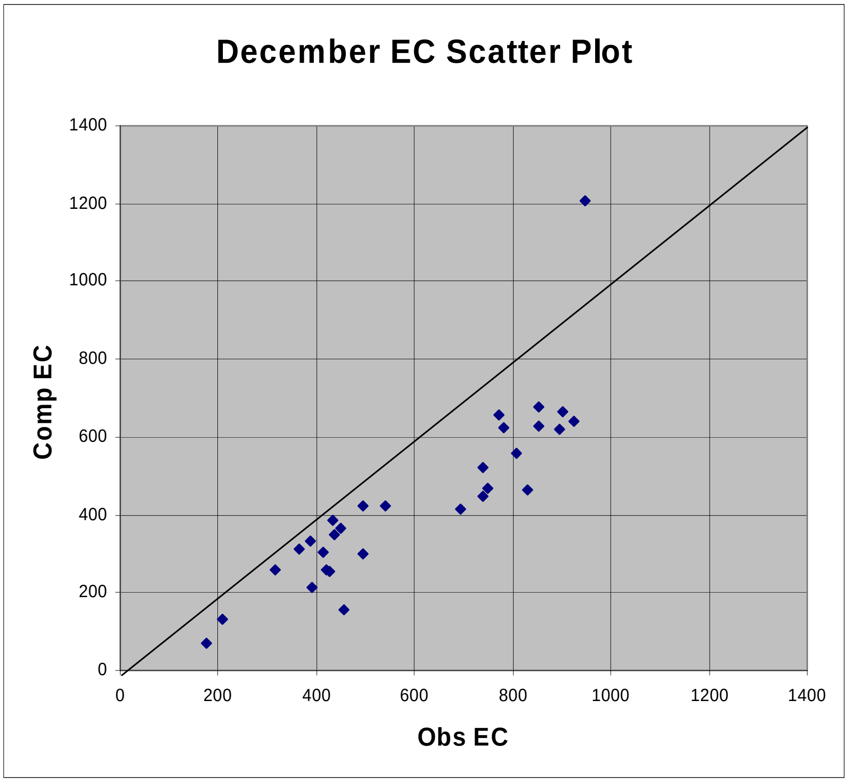

Figure 4-10
December EC Scatter Plot

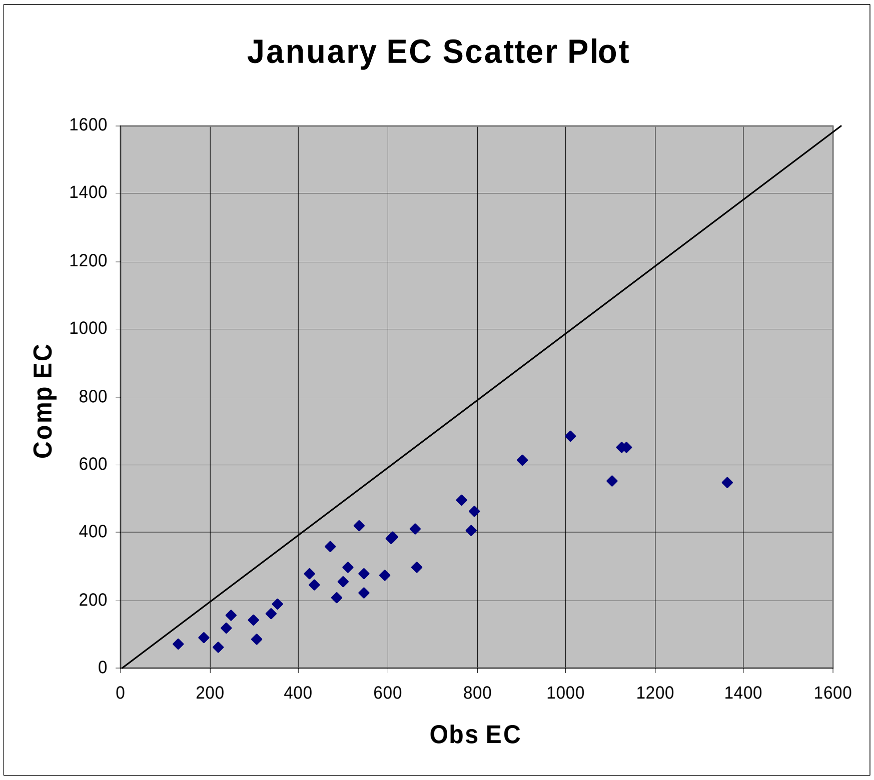

Figure 4-11
January EC Scatter Plot

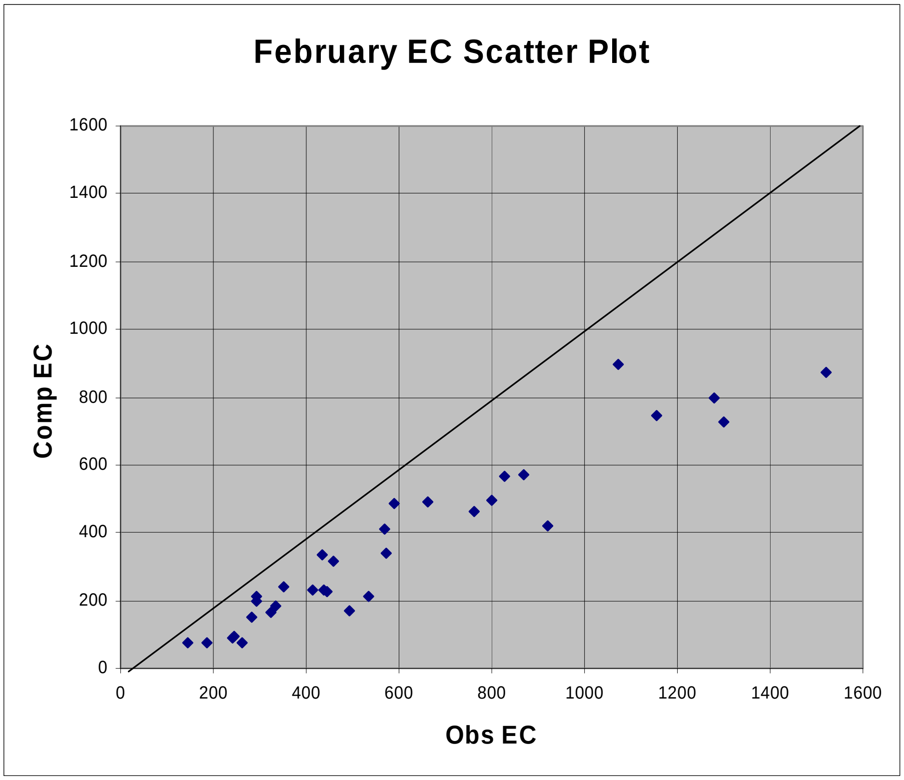

Figure 4-12
February EC Scatter Plot

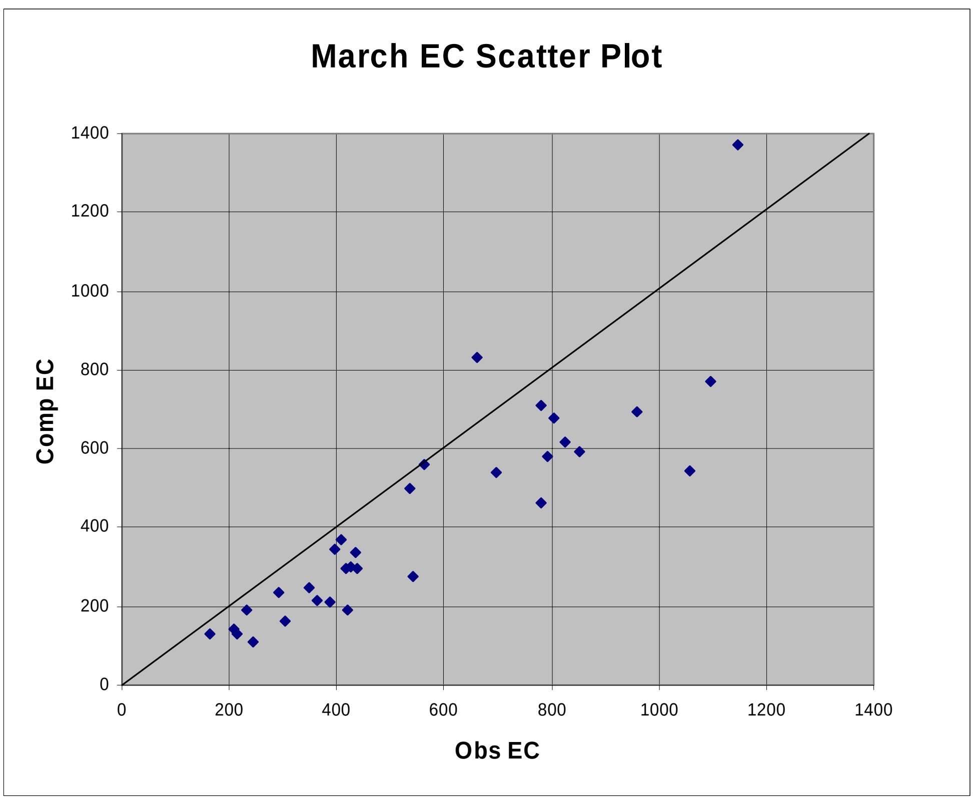

Figure 4-13
March EC Scatter Plot

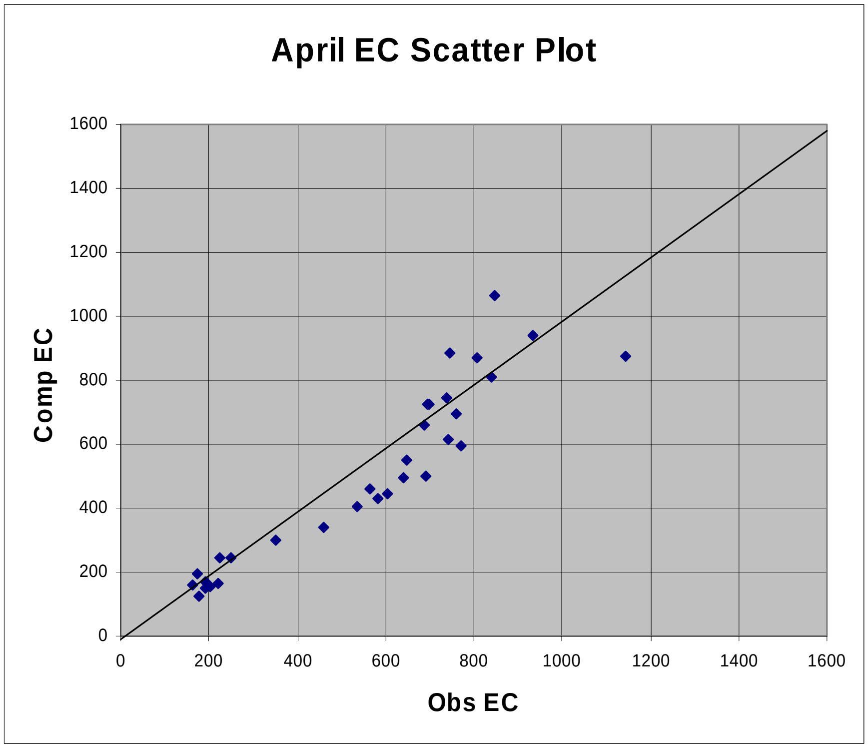

Figure 4-14
April EC Scatter Plot

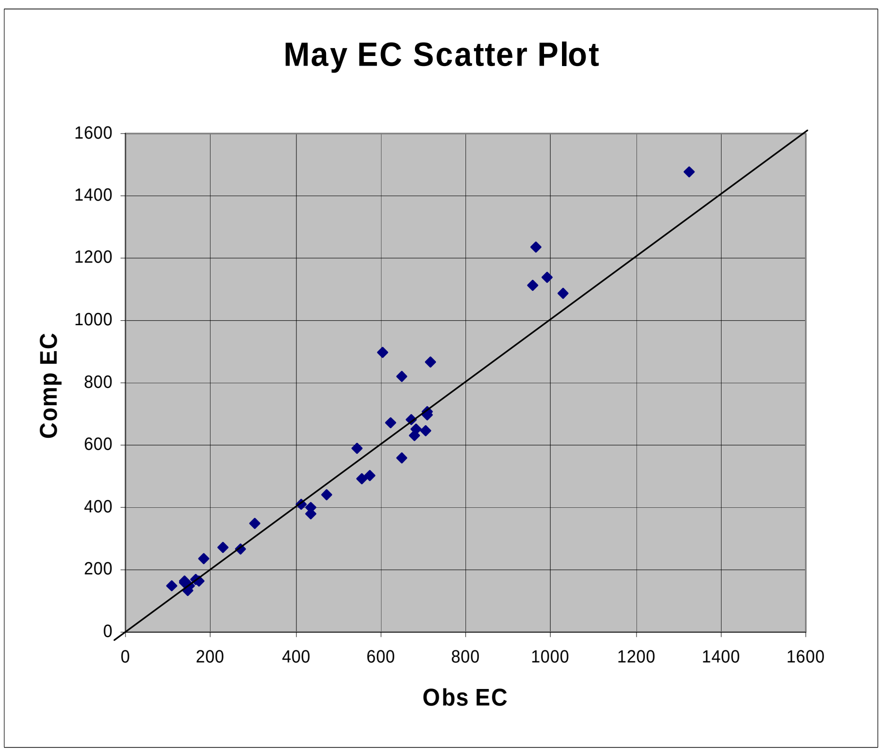

Figure 4-15
May EC Scatter Plot

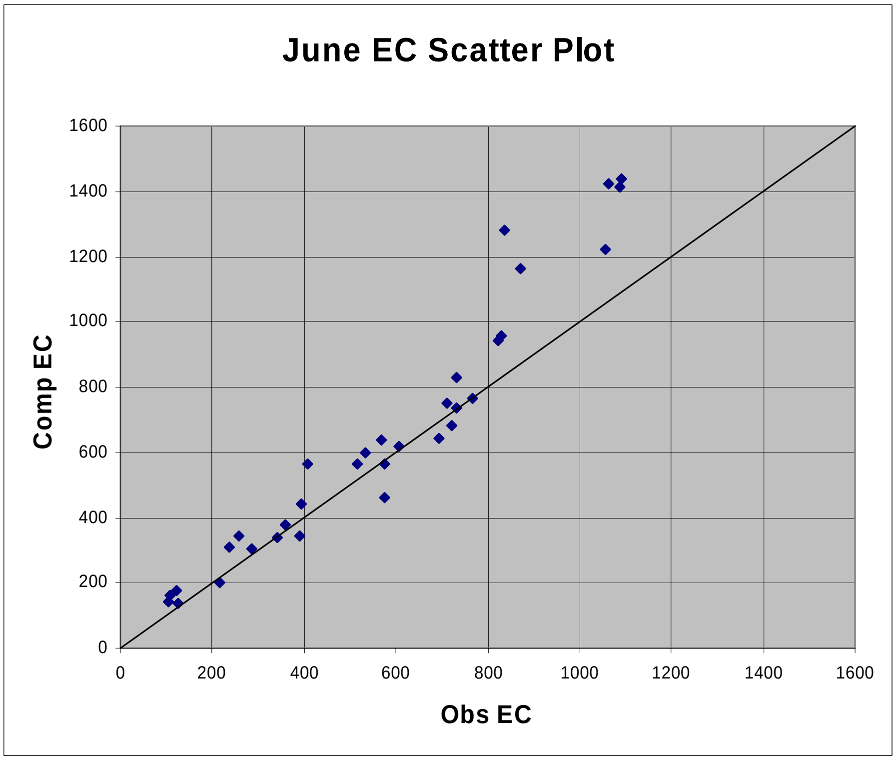

Figure 4-16
June EC Scatter Plot

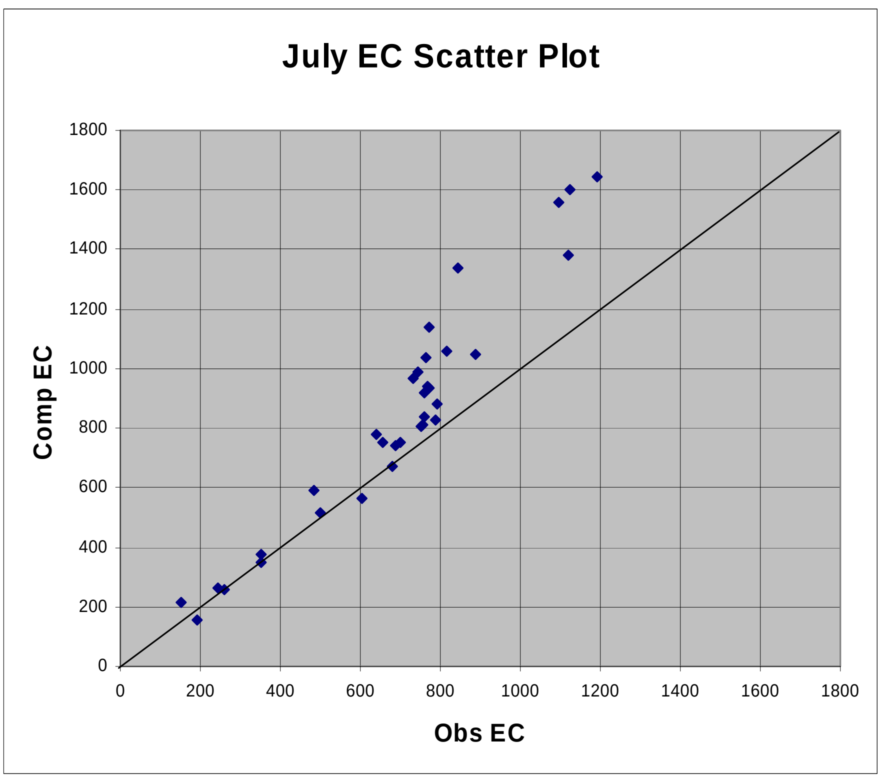

Figure 4-17
July EC Scatter Plot

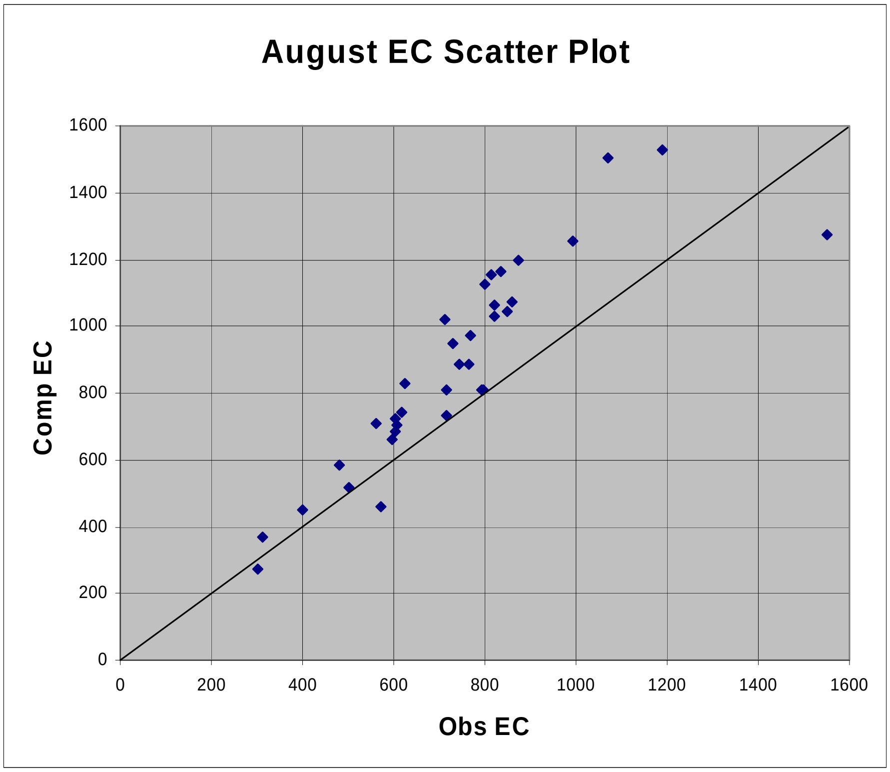

Figure 4-18
August EC Scatter Plot

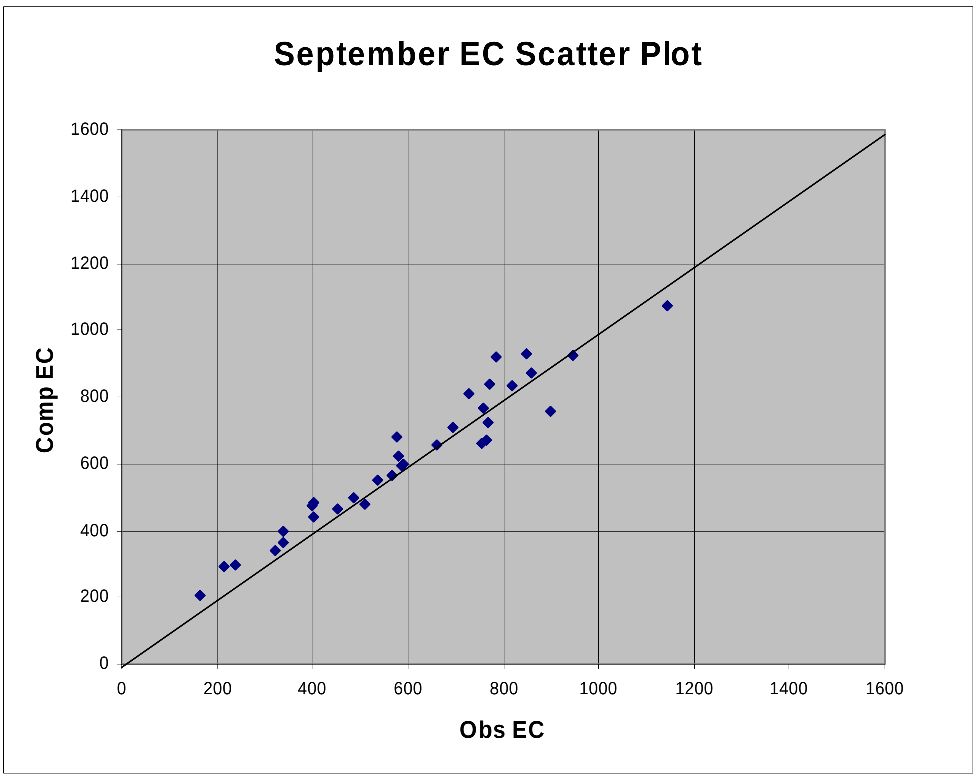

Figure 4-19
September EC Scatter Plot

APPENDIX

CALSIM II WRESL CODE

WQ_Bound.wresl

```
!WRESL statements for San Joaquin River System
!WQ_BOUNDCYCLE6 (bounds within the San Joaquin basin for cycle 6 only: Water Quality )
!Edward Chang
!6/05/2000
!
!Joint Model
!This code bounds decision variables using monthly weighted constraints for cycle 6 only
!Water quality release and remaining CAP calculations; final water quality
!*******************************************************************************************

!*******************************
!*********Water Quality*********
!*******************************
define WQreleasecycle6 {
case April {
condition month  == apr
value     14.*C10WQ[SJR_WQ1]/30. + 16.*C10WQ[SJR_WQ2]/30. }
case MayOnly {
condition month  == may
value     15.*C10WQ[SJR_WQ2]/31. + 16.*C10WQ[SJR_WQ1]/31. }
case otherwise {
condition always
value     C10WQ[SJR_WQ1] }
}

goal capC10WQ1cycle6 { C10WQ = WQreleasecycle6  }
!goal capC10WQ2cycle6 { C10WQ < WQreleasecycle6  }

define remWQrelCAPsv {   !TAF; state variable to be  written to a decision variable
case march {
condition      month == mar
value     max(0.,WQRelCap - C10WQ[SJR_WQ1]*cfs_TAF) }
case April {
condition month == apr
value     max(0.,remWQrelCap(-1) - 14.*C10WQ[SJR_WQ1]*cfs_TAF/30. -
16.*C10WQ[SJR_WQ2]*cfs_TAF/30.) }
case MayOnly {
condition month == may
value     max(0.,remWQrelCap(-1) - 15.*C10WQ[SJR_WQ2]*cfs_TAF/31. -
16.*C10WQ[SJR_WQ2]*cfs_TAF/31.) }
case Otherwise {
condition      always
value     max(0.,remWQrelCap(-1) - C10WQ[SJR_WQ1]*cfs_TAF) }
}
goal setremWQrelCap { remWQrelCap = remWQrelCAPsv }

!************************************
!*****Final Vernalis Water Quality****
!************************************

!Since the computation of the monthly-averaged final water quality at Vernalis includes
!the effects of:
!    1) VAMP,
!    2) Dissolved Oxygen,
!    3) Vernalis Minimum flows,
!    4) ERPP Water, and
!    5) OID reallocated flows,
!the water quality may be below the standard even in a month where water quality releases
!are being made (because water quality releases are computed before any of the above
!requirements

!Westside and Mainstem flows are being redefined here because they were locally defined in a
previous cycle
define WestSideNonPulse { value      max (0.,
WestSide[SJR_WQ1] + min(0., MainStem[VAMP_AND_DO])
) }
```

```
define MainStemNonPulse { value      max (0., C639[SJR_WQ1] - C528[SJR_WQ1] - R638[SJR_WQ1] -
D639[SJR_WQ1] - WestSideNonPulse) }
define WestSidePulse { value  max (0.,
WestSide[VAMP_AND_DO] + min(0., MainStem[VAMP_AND_DO])
)}
define MainStemPulse { value  max (0., C639[VAMP_AND_DO] - C528[VAMP_AND_DO] - R638[VAMP_AND_DO]
- D639[VAMP_AND_DO] - WestSidePulse) }

define MainStem_EC_finalnp {
case JunthruSep {
condition month >= jun .and. month <= sep
value     Vern_WQmult
* pow(MainStemPulse*cfs_AF + R638[VAMP_AND_DO]*cfs_AF,Vern_WQexp)}
case otherwise {
condition  always
value     Vern_WQmult
* pow(MainStemNonPulse*cfs_AF + MercedRelease_Oct*TAF_cfs + R638[SJR_WQ1]*cfs_AF,Vern_WQexp)}
}
define MainStem_EC_finalpulse {
case AprilMay {
condition month >= apr .and. month <= may
value     Vern_WQmult
* pow(MainStemPulse*cfs_AF + R638[VAMP_AND_DO]*cfs_AF
- max (0.,     (C81m[VAMP_AND_DO] - C81m[SJR_WQ1]
- min (0., mainstem[VAMP_AND_DO])
- Demand_D624 - Demand_D625 - Demand_D639)*cfs_AF
)
- C81VAMP[VAMP_AND_DO]*cfs_AF - C20VAMP[VAMP_AND_DO]*cfs_AF
- D16B[VAMP_AND_DO]*cfs_AF, Vern_WQexp)}
case otherwise {
condition always
value     0. }
}
define VERNWQNONPULSE {
case NonPulseNonDO {
condition month <= mar
value      ACCR[SJR_WQ1] * ACCR_EC/flowC639woD639
+ C16[SJR_WQ1] * GOOD_EC/flowC639woD639
+ MainStemNonPulse* MainStem_EC_finalnp/flowC639woD639
+ R638[SJR_WQ1]* MainStem_EC_finalnp/flowC639woD639
+ WestSideNonPulse * WestSide_EC/flowC639woD639
+ VernMin_reqtobemet * GOOD_EC/flowC639woD639
+ MercedRelease_Oct * TAF_cfs * GOOD_EC/flowC639woD639
+ OIDInstreamToBeMet * TAF_cfs * GOOD_EC/flowC639woD639 }
case APRILMAY {     !during the april and may non-pulse period
condition month >= apr .and. month <= may
value       ACCR[SJR_WQ1] * ACCR_EC/flowC639woD639
+ C16[SJR_WQ1] * GOOD_EC/flowC639woD639
+ MainStemNonPulse * MainStem_EC_finalnp/flowC639woD639
+ R638[SJR_WQ1] * MainStem_EC_finalnp/flowC639woD639
+ WestSideNonPulse * WestSide_EC/flowC639woD639
+ VernMin_reqtobemet * GOOD_EC/flowC639woD639 }
case NonPulsePlusDO {
condition always    !June thru September
value       ACCR[VAMP_AND_DO] * ACCR_EC/flowC639woD639
+ C16[VAMP_AND_DO] * GOOD_EC/flowC639woD639
+ MainStemNonPulse* MainStem_EC_finalnp/flowC639woD639
+ R638[VAMP_AND_DO]* MainStem_EC_finalnp/flowC639woD639
+ WestSideNonPulse * WestSide_EC/flowC639woD639
+ VernMin_reqtobemet * GOOD_EC/flowC639woD639
+ OIDInstreamToBeMet * TAF_cfs * GOOD_EC/flowC639woD639 }
}
define VERNWQPULSE {
case APRIL {
condition month == apr
value       ACCR[VAMP_AND_DO] * ACCR_EC/pulseC639woD639
+ C16[VAMP_AND_DO] * GOOD_EC/pulseC639woD639
!The following 5 flows don't include VAMP or pulse flows
+ MainStemPulse * MainStem_EC_finalpulse/pulseC639woD639
- max (0.,     C81m[VAMP_AND_DO] - C81m[SJR_WQ1]
- min (0., mainstem[VAMP_AND_DO])
```

```
- Demand_D624 - Demand_D625 - Demand_D639
) * MainStem_EC_finalpulse/pulseC639woD639
- D16B[VAMP_AND_DO] * MainStem_EC_finalpulse/pulseC639woD639
+ R638[VAMP_AND_DO]* MainStem_EC_finalpulse/pulseC639woD639
+ WestSidePulse * WestSide_EC/pulseC639woD639
!adding the VAMP and pulse flows in with Fresh EC
+ C81VAMP[VAMP_AND_DO] * Good_EC/pulseC639woD639
+ C20VAMP[VAMP_AND_DO] * Good_EC/pulseC639woD639
+ D16B[VAMP_AND_DO] * Good_EC/pulseC639woD639
+ max (0.,     C81m[VAMP_AND_DO] - C81m[SJR_WQ1]
- min (0., mainstem[VAMP_AND_DO])
- Demand_D624 - Demand_D625 -Demand_D639
) * GOOD_EC/pulseC639woD639
!effects of OID reallocated water
+ OIDInstreamToBeMet * 30./16. * TAF_cfs * GOOD_EC/flowC639woD639 }
case MAYONLY {
condition month == may
value       ACCR[VAMP_AND_DO] * ACCR_EC/pulseC639woD639
+ C16[VAMP_AND_DO] * GOOD_EC/pulseC639woD639
!The following 4 flows don't include VAMP or pulse flows
+ MainStemPulse * MainStem_EC_finalpulse/pulseC639woD639
- max (0.,     C81m[VAMP_AND_DO] - C81m[SJR_WQ1]
- min (0., mainstem[VAMP_AND_DO])
- Demand_D624 - Demand_D625 - Demand_D639
) * MainStem_EC_finalpulse/pulseC639woD639
- D16B[VAMP_AND_DO] * MainStem_EC_finalpulse/pulseC639woD639
+ R638[VAMP_AND_DO]* MainStem_EC_finalpulse/pulseC639woD639
+ WestSidePulse * WestSide_EC/pulseC639woD639
!adding the VAMP and pulse flows in with Fresh EC
+ C81VAMP[VAMP_AND_DO] * Good_EC/pulseC639woD639
+ C20VAMP[VAMP_AND_DO] * Good_EC/pulseC639woD639
+ D16B[VAMP_AND_DO] * Good_EC/pulseC639woD639
+ max (0.,     C81m[VAMP_AND_DO] - C81m[SJR_WQ1]
- min (0., mainstem[VAMP_AND_DO])
- Demand_D624 - Demand_D625 - Demand_D639
) * GOOD_EC/pulseC639woD639
+ OIDInstreamToBeMet *  TAF_cfs * GOOD_EC/flowC639woD639
!effects of OID reallocated water
+ OIDInstreamToBeMet * 31./15. * TAF_cfs * GOOD_EC/flowC639woD639
!effects of ERPP
+ 10./15. * SJRERPPinflows * GOOD_EC/ pulseC639woD639 }
case otherwise {
condition always
value     0. }
}
define VernWQfinalSV {   !micromhos/cm; state variable to be  written to a decision variable
case April {
condition month == apr
value     14.*VernWQnonpulse/30. + 16.*VernWQpulse/30. }
case MayOnly {
condition month == may
value     15.*VernWQpulse/31. + 16.*VernWQnonpulse/31. }
case otherwise {
condition always
value     VernWQnonpulse}}

define VERNWQNONPULSEDV {std kind 'Salinity-EC' units 'umhos/cm'}
define VERNWQPULSEDV {lower -99999 upper 99999 kind 'Salinity-EC' units 'umhos/cm'}
define VernWQfinal {lower -99999 upper 99999 kind 'Salinity-EC' units 'umhos/cm'}
goal setWQNOPULSEDV { VERNWQNONPULSEDV = VERNWQNONPULSE }
goal setWQPULSEDV { VERNWQPULSEDV = VERNWQPULSE }
goal setVernWQfinal { VernWQfinal = VernWQfinalSV }
```

Vernalis_Bound.wresl

```
!WRESL statements for San Joaquin River System
!VERNALIS_BOUNDCYCLE6 (bounds within the San Joaquin basin for cycle 6 only: Vernalis )
!Edward Chang
!5/01/2000
!
!Joint Model
!This code bounds decision variables using monthly weighted constraints for cycle 6 only
```

```
!Vernalis monthly averaged flows
!*******************************************************************************************

!*************************
!*****Flow at Vernalis****
!*************************
define Vern_nomincycle6 { !without Vernalis minimum flows from February to June plus October
case NonPulseNonDO {
condition   month <= mar
value       C639[SJR_WQ1] }
case April {
condition   month == apr
value       14.*C639[SJR_WQ1]/30. + 16.*C639[VAMP_AND_DO]/30. }
case Mayonly {
condition   month == may
value       15.*C639[VAMP_AND_DO]/31. + 16.*C639[SJR_WQ1]/31.
+ TuolERPP_wtdef + MercERPP_wtdef + StanERPP_wtdef }
case NonPulsePlusDO {
condition   always
value       C639[VAMP_AND_DO] }
}
goal set1Vernalis_cycle6 { C639 = Vern_nomincycle6 + C10INSTREAM + C10MIN + C20MIN }
!goal set2Vernalis_cycle6 { C639 > Vern_nomincycle6 + C10INSTREAM + C10MIN + C20MIN }


!Vernalis flows during pulse (April and May including ERPP), and non-pulse periods
!for use in computing final water quality based on split month calculations
!ERPP inflows will affect Vernalis flows in May
define SJRERPPinflows {  !10 day CFS for 10 days
case NoERPP {
condition ERPP543 <= 0.1 .and. ERPP563 <= 0.1
value     0. }
case MayOnly {
condition month == may
value     TuolERPP_def + MercERPP_def + StanERPP_def }
case otherwise {
condition always
value     0. }
}
define pulseC639woD639 { !15 day water representing cycle pulse period; weights ERPP for 15 days
case April {        !does not include D639 (Vernalis Non-project Diversion)
condition month == apr
value     C639[VAMP_AND_DO] + OIDInstreamToBeMet*30./16.*TAF_cfs  }
case MayOnly {
condition  month == may
value     C639[VAMP_AND_DO] + SJRERPPinflows*10./15.
+ OIDInstreamToBeMet*31./15.*TAF_cfs }
case NotAprMay {
condition always
value     0. }
}
define flowC639woD639 {       !Vernalis non-pulse flow before the Vernalis Non-project Diversion
case OctthruMay {
condition month <= may
value     C639[SJR_WQ1] + VernMin_reqtobemet + OIDInstreamToBeMet*TAF_cfs
+ MercedRelease_Oct*TAF_cfs }
case DOwindow {
condition always
value     C639[VAMP_AND_DO] + VernMin_reqtobemet + OIDInstreamToBeMet*TAF_cfs }
}
```

WQ_defs.wresl

```
!WRESL code for Water Quality constants definitions
!WQ_DEFS
!Edward Chang
!4/04/2000
!
!Joint Model
!The following code contains the definitions and goals which are common to the pulse and non-
pulse
!Water Quality cycles
!*****************************************************************************************

!Water Quality definitions
!The following is the table
!Uses modified Kratzer Eqn supplied by USBR; 1=IR; 2=NI
!Units: Cap=TAF; Salinity=microseimens/cm; mult&exp=dimensionless
!VERNWQCONSTANTS
!option CAP1STYR       WQSTD   ACCR    GOOD        WestSide         WQMULT          WQEXP
!1      70.            700.    190.    85.            2300.          54645.          -0.44346
!2      70.            1000.   380.    85.            2300.          866201.49       -0.69289

define WQRelCapdv {std kind 'WQ-REL-CAP' units 'TAF'}
define WQRelCap {                     !each march select new Cap based on New Melones forecast
case March {
condition      month == mar
select         NMWQcap from stan_yr given NMF = NMforecast1 use linear }
case other {
condition      always
value          WQRelCapdv(-1) }
}
goal set_WQRelCap {WQRelCapdv = WQRelCap }

define remWQrelCap { std kind 'storage' units 'TAF' }       !remaining WQ cap calculated in Cycle
6
define VernWQstd {             !micromhos/cm; note: Irrigation Season is different than the rest
case Irrigation {
condition      month >= apr .and. month <= aug
select         WQstd from VernWQconstants where option = 1 }
case NonIrrigation {
condition      always
select         WQstd from VernWQconstants where option = 2 }
}
define Accr_EC {
case Irrigation {
condition      month >= mar .and. month <= sep
select         ACCR from VernWQconstants where option = 1 }
case NonIrrigation {
condition      always
select         ACCR from VernWQconstants where option = 2 }
}
define Good_EC {
case Irrigation {
condition      month >= mar .and. month <= sep
select         GOOD from VernWQconstants where option = 1 }
case NonIrrigation {
condition      always
select         GOOD from VernWQconstants where option = 2 }
}
define WestSide_EC {
case Irrigation {
condition      month >= mar .and. month <= sep
select         WestSide from VernWQconstants where option = 1 }
case NonIrrigation {
condition      always
select         WestSide from VernWQconstants where option = 2 }
}
define Vern_WQmult {
case Irrigation {
condition      month >= mar .and. month <= sep
select         WQmult from VernWQconstants where option = 1 }
```

```
case NonIrrigation {
condition      always
select         WQmult from VernWQconstants where option = 2 }
}
define Vern_WQexp {
case Irrigation {
condition      month >= mar .and. month <= sep
select         WQexp from VernWQconstants where option = 1 }
case NonIrrigation {
condition      always
select         WQexp from VernWQconstants where option = 2 }
}
```